Volume 19 February, 1933 *Number 2*

Lubrication

A Technical Publication Devoted to
the Selection and Use of Lubricants

THIS ISSUE

**Air Conditioning—
The Lubrication Factor**

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

Published by

The Texas Company, 135 East 42nd Street, New York City

Vol. XIX February, 1933 No. 2

Change of Address: In reporting change of address kindly give both old and new addresses.

Air Conditioning— The Lubrication Factor

REFRIGERATION, or the production of controlled cold conditions, has been studied for upward of a hundred years in full appreciation of its necessity for the preservation of meats, beverages, foodstuffs and furs during storage periods. Refrigeration as a means of controlling air conditions, however, is a comparatively recent development. The enthusiasm with which it has been received fully justifies the intensive efforts which its sponsors have given in the interest of public health and personal comfort. Working conditions in particular can be vastly improved by application of air conditioning and judicious use of refrigeration, for both men and machinery function at their best when working conditions are favorable.

The four principal conditions which are essential to comfort and brought about by air conditioning involve

- correct temperature,
- the proper degree of humidity,
- adequate circulation of air, and
- ventilation, by admission of fresh air to the closed space to be conditioned.

The machinery required for the accomplishment of the above would seem to be intricate. Study of the working details, however, proves that the normal cycle of refrigeration plus proper control of air currents are the basic factors.

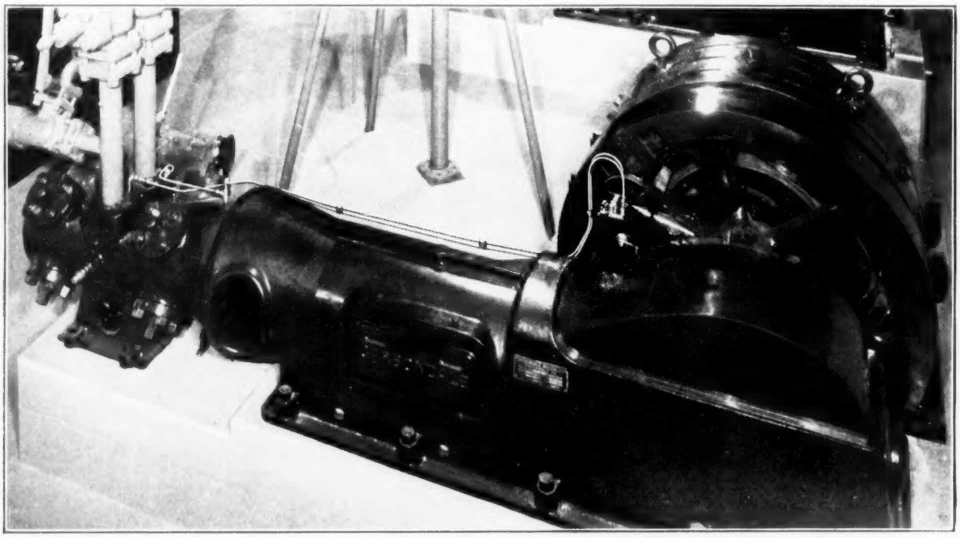
Air conditioning especially from the viewpoint of comfort cooling is a function of indirect refrigeration. Actual accomplishment of this latter requires (1) absorption of heat by evaporation and expansion of the refrigerant, and (2) compression and condensation whereby this heat is in turn abstracted from the refrigerant, the latter being converted to liquid form to enable it to qualify once again as a heat absorbing medium.

Until recently anhydrous ammonia (NH_3) or ammonia free from water was most commonly used in straight refrigeration work, supplemented by carbon dioxide where the specific advantages of the latter were desirable. The development of household refrigeration, however, led to intensive study of other refrigerants, more or less suited to such service by reason of their adaptability to lower pressures and the equipment available. Among these products are ethyl and methyl chlorides, sulfur dioxide, dichloromethane (CH_2Cl_2), certain hydro-carbons such as ethane, propane, iso-butane, and butane, and most recently Freon, or F-12, chemically known as dichlorodifluoromethane.

REFRIGERATION BY COMPRESSION

Modern air conditioning machinery makes extensive use of the principles of compression in bringing about the necessary refrigeration. Dependent upon the type and size of unit, either a reciprocating or centrifugal type of compressor can be used. The latter is particularly unique by reason of the constant pressures

available, its positive action and the minimum of wearing elements. From a lubrication point of view this latter is of decided interest, for only two bearings are involved. No internal lubrication is required, which is a decided advantage, inasmuch as there is, therefore, no possibility of accumulation of objectionable carbonaceous or non-lubricating deposits to interfere with free movement of the working parts.



Courtesy of The Carbondale Machine Company

Fig. 1—External view of a Carbondale carbon dioxide compressor, showing installation of Bowser Model T mechanical force feed lubricator. Note there are two connections from this latter, one entering the bottom of the stuffing box. From the top of this latter a vent line leads to the suction of the compressor, at which is mounted a gauge for observation of the pressure at the stuffing box vent. The other oil pipe is led to the center of the cylinder barrel on the top.

As yet, however, the centrifugal or rotary type of compressor is only adaptable to comparatively large air conditioning units. The average household unit employs the vertical reciprocating type of machine, of trunk type construction, wherein lubrication is brought about by splash circulation as the cranks rotate in the crankcase.

Utilization of Latent Heat

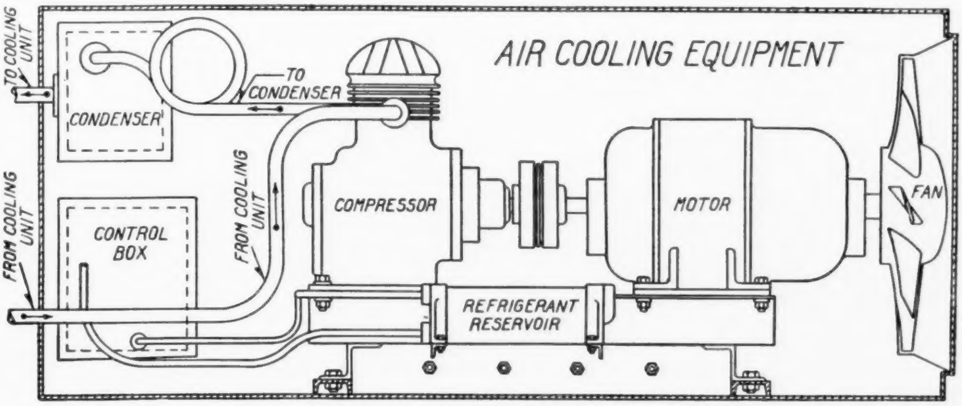
In development of refrigeration by compression the latent heat of the refrigerating medium is utilized in extracting heat from air, water or brine prior to their circulation through the cooling element or space to be cooled. The essential equipment includes the driving element which is normally an electric motor, the refrigerant reservoir, compressor, condenser, expansion valve, oil separating unit and evaporator or cooler.

Compressors of the reciprocating type may be either single or double acting, according to the size of the installation and extent of refrigeration required. Considerable study is also being given to development of a two stage type. On the other hand, in selection of lubricants for such operations the higher temperatures ranging up to perhaps 180 deg. Fahr., must be taken into consideration. The function of the compressor is to recover the refrigerant or cooling agent after it has been evaporated in the cooling chamber or evaporator. The purpose of the compression process is to convert the gaseous refrigerant back to liquid form by adequate compression and cooling. Under compression alone the refrigerant would still remain as a gas, due to the fact that the application of pressure raises the temperature above the liquefaction point. Condensation and cooling are therefore essential.

Prior to condensation, however, the gas is usually passed through a suitable oil separator or trap, in order to free it of any excess lubricant that may have gained entry into the compressor. From the oil separator the hot refrigerant then passes to the cooling coils of the condenser, where its temperature is sufficiently lowered by means of air or cold circulating water, to convert it to liquid form. It is then capable of serving as a cooling medium. This is brought about by passing it through an expansion or regulating valve to the expansion side of the system. Here by virtue of a considerable drop in pressure its temperature is lowered to such a point that it is capable of absorbing heat from its surroundings. This absorption of heat reduces the temperature of the surrounding medium, which in air conditioning is the room air to be cooled, and causes the cooling medium or refrigerant to boil, which converts it into a gas. It is then returned to the compressor to commence this cycle of operation anew.

REFRIGERANTS ADAPTABLE

In air conditioning work effort has been made to employ refrigerants of the non-toxic type which would be relatively harmless should leakage occur. The extent to which some have proved suitable has exerted a marked influence toward their consideration by leading manufacturers of machinery for such work, in direct contrast with the use of ammonia, and sulfur dioxide, which are employed in more purely refrigeration service.



Courtesy of Westinghouse Electric and Manufacturing Co.

Fig. 2—Showing a Westinghouse refrigerating unit for railway passenger car air conditioning service. The driving motor is equipped with ball bearings, the compressor itself being fitted with sleeve type bearings which are lubricated from a force feed oiling system. In view of the fact that Freon, or F-12, is used as the refrigerant, and is miscible with oil, utmost care must be given to selecting an oil which will insure effective lubrication at low temperatures, even when diluted with the refrigerant.

Chlorinated Hydrocarbon Compounds

Methyl chloride has long been used as a refrigerant by manufacturers of household refrigerators and small commercial apparatus. While it is practically odorless, it is customary for the manufacturers of this chemical to add an odorant called Acrolein to it as a warning agent. Because of its toxicity even in extreme dilution it is not likely to be employed in direct expansion air conditioning systems or room coolers.

Dichloromethane or methylene chloride, known commercially as Carrene, is used extensively in air conditioning refrigerating apparatus of the centrifugal type. Such apparatus is run under a vacuum on both the "high" and "low" sides and consequently there is little likelihood of the refrigerant leaking to the atmosphere and creating a hazard. Safety engineers consider it a safe refrigerant under the conditions of use.

Ethyl Chloride has also been used as a refrigerant but not extensively due to its flammability and explosive nature. For this reason but little interest has been shown in its usage in the air conditioning field.

The chlorinated hydrocarbons are as a rule inert to the metals used in refrigeration equipment. While some of them are flammable and explosive, others are relatively non-flammable and non-explosive.

Halo-Fluoro Derivatives of the Aliphatic Hydrocarbons

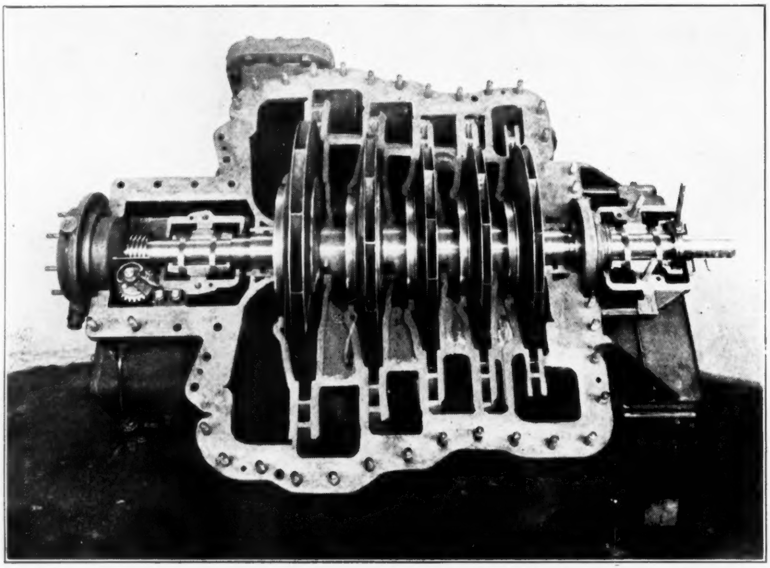
The halo-fluoro derivatives of the aliphatic hydrocarbons contain one or more fluorine atoms. Dichlorodifluoromethane, commercially known as Freon or F-12, is the best known of these products. They are highly preferred for air conditioning systems due to their extremely low toxicity, being even less toxic than carbon dioxide.

Freon is practically non-soluble in water and does not alter the taste of drinking water; furthermore, it has no effect on furs and most foodstuffs. Its mixtures with air are practically odorless and if a system installed in a theater or other public place should leak, there would be no panic of the audience as they would not even know that they were being exposed to its vapor. They also could not be injured because concentrations as great as twenty percent may be inhaled for a long period of time without causing any organic disturbance. These products are also non-corrosive to the metals which are used in refrigeration equipment and are non-flammable and non-explosive. Leaks of these refrigerants are easily detected by means of a halide lamp and the Underwriters' Laboratories say concerning dichlorodifluoromethane "The hazards to health resulting from exposure to dichlorodifluoromethane when used as a refrigerant are judged to be remote. Consideration of available data indicates that dichlorodifluoromethane is in a class with the practically non-toxic gases."

Hydrocarbon Compounds

The aliphatic hydrocarbons, such as ethane, propane, butane and iso-butane, have some-

times been used as refrigerants. At the present time they are not being considered for use in air conditioning equipment due to their inflammability and explosive nature. In consequence they should not be used where leakage would mean exposure to open flame.



Courtesy of Carrier Engineering Corporation

Fig. 3—Showing lower half of a Carrier 5 stage centrifugal type compressor. At left note worm driven oil pump and ring oilers. At right note ring oilers and vacuum seal. The only contact of moving parts is at main shaft bearings.

Carbon Dioxide

Refrigeration by means of carbon dioxide, or carbonic anhydride (CO_2) as it is also known, involves an arrangement of machinery and equipment much similar to an ammonia compression system. In fact, the essential difference (other than in regard to certain details of construction in view of the higher pressures involved) is in the cooling medium or refrigerant employed.

Carbon dioxide is non-explosive, odorless, non-combustible, a fire extinguisher and neutral in its action upon foodstuffs, fabrics and other substances which may require cold storage. Normal leakage is, therefore, not generally harmful even though it may be more prevalent due to the higher pressures involved.

Carbon dioxide systems include both horizontal and vertical compressors, according to the type of service and refrigerating capacity involved.

Single and double acting compressors are in use, but due to the difficulty in maintaining tight stuffing boxes the single acting machine is often preferred. Frequently pressures as high as 1,000 pounds or more may be necessary; therefore, it is evident that the system must be of exceptional rigidity.

METHODS OF LUBRICATION

Compressor lubrication must, of course, be studied according to the type of machine and the prevailing means for circulating oil to the moving or contact parts. In the centrifugal compressor bearing lubrication will be of chief interest, ring oilers being largely used for this purpose. The reciprocating machine, however, brings in the problems of both bearings and cylinders, the one oil usually being called upon to serve throughout.

Lubrication, on the other hand, is not the only point of consideration for the effects of congealed oil in certain parts of the system, as well as admixture with refrigerant with consequent change in the physical nature of the oil must also be studied. This will be particularly true where refrigerants of chloride combinations are involved. The opinion of Kinetic Chemicals, Incorporated,* with particular respect to Freon (dichlorodifluoromethane) is of distinct interest in this regard.

"The lubrication of a Freon charged compressor is similar to that of a compressor using a refrigerant that is completely miscible with mineral lubricating oil, such as methyl chloride. Since Freon and mineral oil are completely miscible, an oil of higher viscosity is required than when using a refrigerant that is not miscible with the lubricating oil.

"The proper selection of a lubricating oil can only be made after having obtained a clear understanding of the physical conditions under which the compressor and system is to be operated. Factors which must be taken into account are, bearing loads, rubbing speeds, type compressor (enclosed or open frame), type compressor (air or water-cooled), temperature of evaporator, type evaporator (flooded or dry expansion), etc.

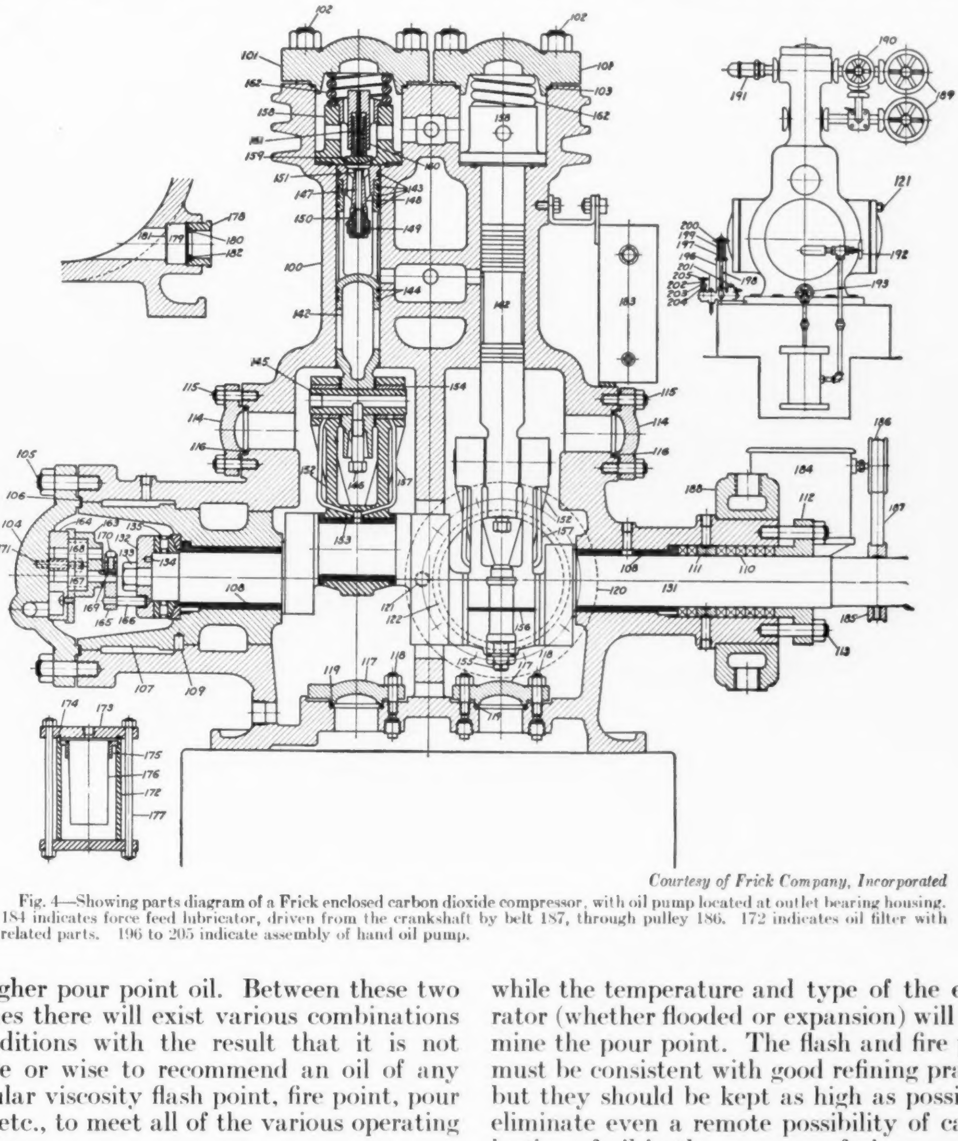
"With this group of factors which are quite variable, an almost endless number of combinations can be produced which will require lubricating oils of various characteristics.

"It must be recognized that a small capacity, low horsepower, slow speed, enclosed type, air-cooled compressor operating a flooded evaporator at temperatures well below the freezing point of water, will function efficiently with a

*Technical Paper No. 11, by R. J. Thompson, Kinetic Chemicals, Inc.

very light, low viscosity and low pour point oil. While in contrast, a large capacity, high horsepower, high speed, water-cooled compressor using trunk type pistons or an open frame, operating a flooded evaporator well above the freezing point will require a higher vicosity point approximately 575 deg. Fahr., and a pour point of 0 deg. to possibly 15 deg. Fahr., may be used.

"Capacity and type of compressor (whether air-cooled or water-cooled) principally will determine the viscosity of the oil to be used,



Courtesy of Frick Company, Incorporated

Fig. 4—Showing parts diagram of a Frick enclosed carbon dioxide compressor, with oil pump located at outlet bearing housing. 184 indicates force feed lubricator, driven from the crankshaft by belt 187, through pulley 186. 172 indicates oil filter with related parts. 196 to 205 indicate assembly of hand oil pump.

and higher pour point oil. Between these two extremes there will exist various combinations of conditions with the result that it is not possible or wise to recommend an oil of any particular viscosity flash point, fire point, pour point, etc., to meet all of the various operating conditions.

"For small domestic refrigerating systems of the enclosed type, an oil of 150 (for flooded systems) to 300 (for expansion systems) viscosity, flash point 350 to 425 deg. Fahr., fire point 390 to 475 deg. Fahr., and a pour point of —10 to —30 deg. Fahr., may be used with complete satisfaction considering the operating conditions.

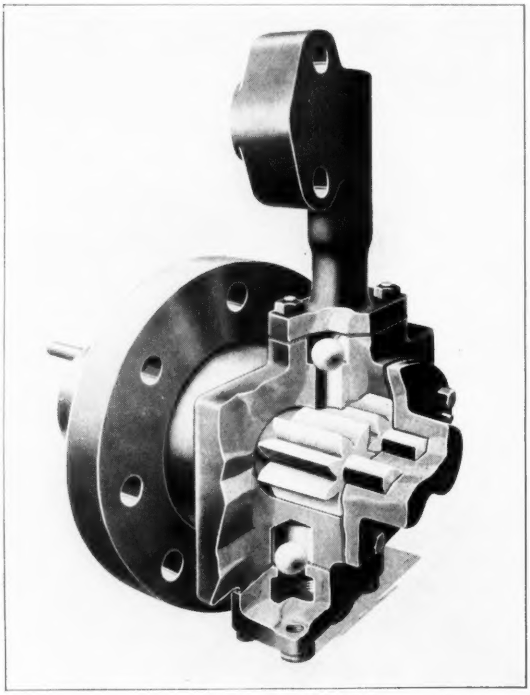
"For large air conditioning compressors of the enclosed type, an oil of up to 900 viscosity, flash point approximately 475 deg. Fahr., fire while the temperature and type of the evaporator (whether flooded or expansion) will determine the pour point. The flash and fire points must be consistent with good refining practices but they should be kept as high as possible to eliminate even a remote possibility of carbonization of oil in the presence of air or water or both.

"The lubricating oil for use with Freon charged compressors should be a straight run and properly refined mineral oil and obviously must not contain water, sediment, acid, soap, resin or any substance not derived from petroleum and must not form wax or gum in the presence of Freon. Also, the oil must not corrode any metal used in refrigeration construction.

"The use of glycerine or ethylene glycol (not

miscible with Freon) is not recommended, as glycerine is highly hygroscopic and in addition has the tendency to become gummy or produce a sticky sludge on surfaces when the compressor or system is idle or when the lubricant is heated.

"Mineral lubricating oils must be thoroughly



Courtesy of Frick Company, Incorporated

Fig. 5—Showing internal view of a Frick gear type oil pump, which insures continual re-circulation of oil.

dehydrated, not because of any chemical reaction but for the reason that any moisture in the oil will freeze out and thus restrict the flow of refrigerant through the regulating valve.

"The question may arise as to the manner in which the oil contained in the flooded evaporator will return to the compressor crankcase, and in the following will be given an explanation as to this question. As the evaporator absorbs heat and the gas bubbles rise to the surface of the Freon-oil solution, the oil film of the bubble is ruptured and these finely divided oil particles form a mist in the Freon vapor and are swept along by the gas stream formed by the ebullition of the refrigerant. These oil particles or oil fog will blanket the Freon-oil solution to a height or thickness in the evaporator which may be predetermined by experiment and will be dependent upon evaporator temperature, capacity, design, location of oil vapor return tube in relation to Freon-oil solution and also the characteristics of the oil itself.

"The Freon vapor which is being returned to the compressor will carry this oil fog through the suction line and return the lubricating oil to the compressor crankcase (closed type), cylinders (trunk or open frame type compressor) or oil interceptor, as drops of oil.

"Oil logging of the flooded evaporator will occur, should the suction or oil fog return tube be placed too high above the surface of the boiling liquid refrigerant, which will permit the oil fog to settle back into the Freon-oil solution. Frosting or sweating of the return line will occur, should the suction tube be placed too close to the surface of the boiling refrigerant where particles of liquid Freon may be splashed or drawn into and vaporized in the return line to the compressor. There will be no oil logging of evaporators of an expansion system due to the high velocity of refrigerant vapor or gas in the return line pushing along any oil particles.

"Freon absorbs small quantities of mineral oil depending on the oil characteristics (pour point and viscosity), the temperature of the oil in the crankcase and the operating back pressure in the compressor crankcase, but unlike other refrigerants (other than hydrocarbon refrigerants) does not deposit the lubricating oil in the low side of the system and cause oil logging.

"The figures given in the accompanying table will show the per cent by weight of Freon absorbed in 150 viscosity (—30 deg. Fahr., pour point) mineral oil at various back pressures and oil temperatures. More Freon will be absorbed by the oil at higher pressures and at lower temperatures, or vice versa. Lighter oils absorb less and heavier oils absorb more Freon than the oil used in the following table.

"Percent Freon (by weight) in 150 viscosity oil."

Operating back pressure pounds per square inch gage	Oil Temperature Degrees Fahr.					
	60	80	100	120	140	160
0	8.5%	6.5%	5%	3.5%	2.5%	2%
10	15	11	8	6	4.5	3.5
20	23	15	11	8.5	6.5	5
30	32	21	14.5	11	8.5	6.5
40	44	27	18.5	13.5	10	8

"During the off-cycle of the compressor, the oil temperature is lowered and the back pressure is increased which will permit the Freon vapors to become absorbed by and condensed in the mineral oil. At the time the compressor starts operation, the back pressure in the low side crankcase is suddenly reduced with the result that the Freon in solution with the crankcase oil will boil out causing the lubricating oil to foam. Should the system be overcharged with oil, this foaming oil will be scrubbed through the intake and discharge

valves and the excess amount of oil in the crankcase will soon pass into the receiver and into the low side of the system. When the compressor is charged with the proper amount of oil there will not be excessive splashing of oil by the eccentrics or crankshaft and the foaming of the oil will not cause faulty operation of the compressor or evaporator.

"Small tonnage compressors using the splash system of lubrication which return the refrigerant vapors and oil direct to the compressor crankcase, may have oil level regulating devices or controls. Small capacity units designed for household installation should not be overcharged with oil and since this oil charge may be very easily controlled, there is no occasion for using oil level regulating devices.

"The foregoing remarks apply to compressors where the Freon vapors return direct to the crankcase.

"Enclosed compressors using trunk type pistons and pressure lubricating oil pumps will not cause any difficulty from foaming and scrubbing of oil, for three reasons: 1. Solubility of Freon in the oil in the compressor crankcase is greatly reduced in this type of compressor; 2, the oil splash or spray in the crankcase is reduced; and 3, no movement of refrigerant vapors through the crankcase and pistons to carry the oil particles in suspension. When pressure lubricating systems are used the oil pump should be placed at the lowest point, or priming devices should be provided, in order to keep pump primed with oil at all times.

"In the larger tonnage machines certain builders prefer to use a semi-open-frame type of compressor wherein the refrigerant vapor will return direct to the cylinder block. By separating the crankcase from the cylinders the lubricating oil contained in the crankcase will have no contact with the Freon vapors and obviously, no foaming of oil will occur. In this type of compressor a predetermined amount of lubricating oil must be added to the Freon liquid to provide for the proper lubrication of the pistons and valves or any device used to circulate the liquid refrigerant."

Splash Oiling Systems

By reason of the enclosed nature of the reciprocating type of compressor adaptable for air conditioning refrigeration work, splash lubrication is suited to the requirements, especially where compressors of vertical design are employed, operating with refrigerants of the hydrocarbon or chloride type.

The principles of operation constitute distribution of the oil at each revolution of the crank, the level in the crankcase being maintained just high enough to permit the crank to dip and splash the necessary amount of oil to the cylinder walls, etc. Continued operation will result in the crankcase being filled with a lubricating vapor above the main body of oil, which will also insure adequate lubrication of main, wrist pin and crank pin bearings. When re-charging the case with oil the level must never be raised too high. Otherwise, oil would be churned by the crank, bringing about such violent agitation as oftentimes to preclude effective precipitation of any impurities that may have gained entry. There would also be possibility of loss of lubricant past the piston rings, with subsequent entry of an excess of oil into the condensing and evaporating parts of the system, or increase in the rate of mixture with the refrigerant. This can be partly overcome by proper adjustment of the piston rings. Where the latter are not sufficiently tight, if the crankcase contains too much oil or agitation is too violent, the excess which naturally will reach the cylinder walls will tend to work past the rings.

Not only is it wasteful, but a detriment, for oil in the refrigerating lines will impose an added load on the oil separator. Furthermore, if by chance the oil is not of sufficiently low pour test there will be a possibility of its congealing within the system, to act as an insulator and reduce refrigeration to a marked degree. The presence of oil in the system may also cause a higher condenser pressure by reason of the vapor pressure produced by the oil.

Use of excess oil in a splash lubricated system will also involve the possibility of difficulty when draining and cleaning, especially where sludging has taken place. Churning of certain oils in a crankcase will give rise to sludge formation if they have not been very highly refined. In part, this is due to oxidation; it will be most probable where water is present or the oil is laden with foreign matter, such as dirt, metallic particles, or carbon.

It is, therefore, important to follow regular periods for cleaning, and to look carefully into the condition of the used oil, for this will very often indicate both the approximate suitability of the latter and the extent to which effective lubrication is being attained.

Pressure Lubrication

Larger types of vertical or horizontal refrigerating machines can be served by pressure lubrication with marked success. With such a system, more accurate control of the amount of oil delivered to cylinder walls and compressor bearings is made possible. On the other hand, it may require more equipment, piping, etc., frequent filling of the reservoir (where a mechanical force feed lubricator is installed) and more attention from the operator than where splash lubrication is involved.

One of the chief advantages of pressure lubrication, however, is the possibility of effective filtration or purification of the oil where there is provision for circulation, in the interest of reducing sludge formation.

Mechanical force feed lubricators can be used where compressor cylinders are to be pressure oiled. Excellent economy will be attained by regulating such lubricators so that just enough oil is delivered to maintain the requisite lubricating films, with the least amount of excess to drain off.

On many types of machines it is good practice to lubricate internal and external parts individually. In other words, using the mechanical lubricator with perhaps three outlets for cylinder and stuffing box service and an independent gravity or mechanical pressure circulating system for all other bearings.

Pressure lubrication is especially adapted to cylinder and rod lubrication via the oil lantern, or oil recess within the piston rod stuffing box. By properly constructing a stuffing box with a lead to come from the lubricator, it is possible to operate the piston rod continually through a ring of oil. In this way effective rod lubrication, as well as sealing against pressure, can be maintained.

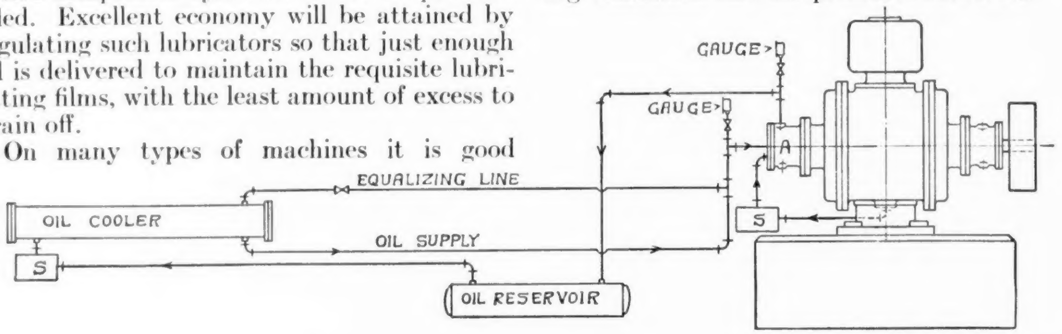
To lubricate the cylinder in addition, it is only necessary to deliver additional oil to the stuffing box lantern and provide a so-called overflow pipe to carry this to the refrigerant suction line adjacent to the cylinder. In effect, this is similar to the principles of steam cylinder lubrication, the refrigerating gas being impregnated with vaporized lubricant prior to its passage through the compressor.

Hand pump oilers can also be used for this purpose, but mechanical force feed lubricators are more positive and require less attention on the part of the operator.

Carbon Dioxide Requirements

Pressure lubrication in air conditioning service is especially adapted to the carbon dioxide compressor. This latter differs from the usual type of machine intended for service with methyl chloride, or Freon, in that the higher pressures will require considerably heavier construction.

Cylinder temperatures will also be somewhat higher due to these pressures. For this reason, individual study must be given to lubrication and positive means for oil delivery. For such machinery the lubricant should be a straight mineral oil, having a low pour test, and a viscosity ranging from 100 to 300 seconds Saybolt at 100 deg. Fahr., dependent upon operating conditions and the pressures involved.



Courtesy of The Vilter Manufacturing Company

Fig. 6—A diagrammatic view of oil cooling and lubrication equipment applicable to a Vilter rotary type compressor. Note location of oil pump at A, with two oil screens located at S, one adjoining the oil cooler, one adjoining the compressor. Arrows indicate direction of flow of oil.

It is interesting to know that mineral oil has no affinity for carbon dioxide, hence there is little or no possibility of its being carried over into the condenser unless it is atomized. This latter is not likely to occur, however, when the oil is suited to the requirements, and the machine has been properly designed.

On the other hand, to insure against an undue excess of oil passing over into the system, an oil trap is usually installed in the discharge line from the compressor.

Stuffing boxes are built similar to those on a double-acting ammonia compressor, with the exception that the higher pressures involved require more compartments to prevent leakage.

Pressure lubrication is the usual means provided for serving the piston rod and maintaining an adequate stuffing box seal. The same system usually serves the compressor valves and piston as well. The feeding of a suitable amount of lubricant to the stuffing box prevents loss of gas.

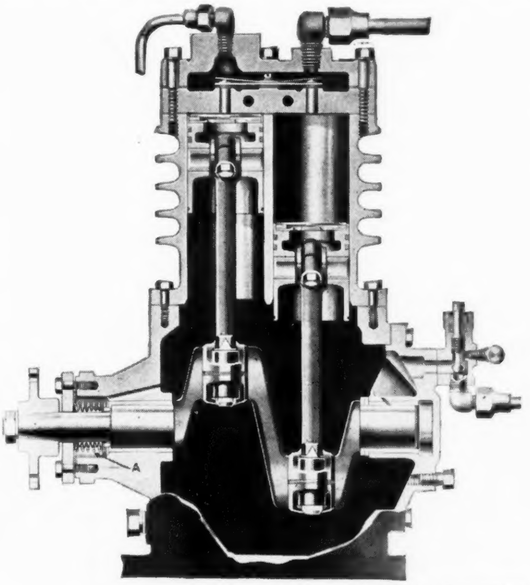
Flow of oil must be very carefully adjusted at all times, however, since the feeding of an excessive supply of oil may result in a certain amount of it passing to the gas relief line and thence into the system.

Ring Oilers

The ring oiler has been widely adopted by builders of centrifugal compressors, due to the comparative simplicity, cleanliness, the extent to which automatic lubrication is developed, the small amount of attention required, the economy, and the uniformity and regularity of oil distribution.

In construction such an oiler comprises a bearing housing which is built with a reservoir and a slot of sufficient width and depth to per-

mit one or more rings or collars suspended from the shaft to revolve therein. As a result, with the revolution of the shaft, these elements, being subjected to rotation, will carry a flood of oil to the top of the shaft, from whence it is able to flow into the bearing oil grooves and



Courtesy of Frigidaire Corporation

Fig. 7—Showing the distinctive constructional features of a Frigidaire compressor applicable to air conditioning service. A indicates Frigidaire patented Durex bushing, which positively seals oil and refrigerant in the crankcase. A self-oiling bearing is seated on the shaft.

clearance space to be ultimately distributed to the entire wearing surface.

After the oil has passed through the bearing, it flows out to the end or ends to be directed through a suitable return chamber which is part of the bearing housing, back to the oil reservoir below.

Oil which is carried to the top of any such bearing must be returned to the reservoir as rapidly as it is delivered by the ring, in order to avoid undue accumulation in the upper part of the housing. The same condition may arise if the oil is carried too high in the well, or if the ring rotates at too high a speed. This will cause a splashing and churning of the oil.

Ring oilers are not usually recommended for bearings below two inches in diameter, especially where high speeds are involved, due to occurrence of excessive slippage of the rings, and the possibility of foaming arising in the oil where reservoir capacities are limited.

Handling of oil in this manner is today regarded by many as the simplest adaptation of the most efficient method of lubrication whereby the bearings are flooded with a considerable excess of oil over the amount that would theoretically be necessary to furnish the requisite oil film. By flooding the bearing with oil the latter serves not only as a lubricant, but also as a cooling medium to carry away part of the frictional heat developed, thereby reducing the temperature of operation If the oil reservoir in the base of the bearing has been properly designed and is of sufficient capacity, this overheated oil will have ample opportunity to rest and become sufficiently cooled after each circulation by contact with the reservoir walls, particularly if the radiation of the latter is not interfered with. Settling out of sediment and other foreign matter will also be facilitated.

Lubricating systems of this nature possess natural advantages in that the flood of oil which is constantly passing through the bearings tends to wash out any grit, dirt, dust or metallic particles that may have gained entry, as a result reducing wear to a minimum. On account of this washing action of the oil, however, the reservoir will gradually tend to accumulate a certain amount of sedimentary deposits. Therefore, it should be flushed out and cleaned at intervals, the old oil being replaced with new or purified oil. This is especially important when such a system is new and core sand, etc., may be present. In such cases several frequent changes are recommended.

Function of Oil in The Centrifugal Compresser

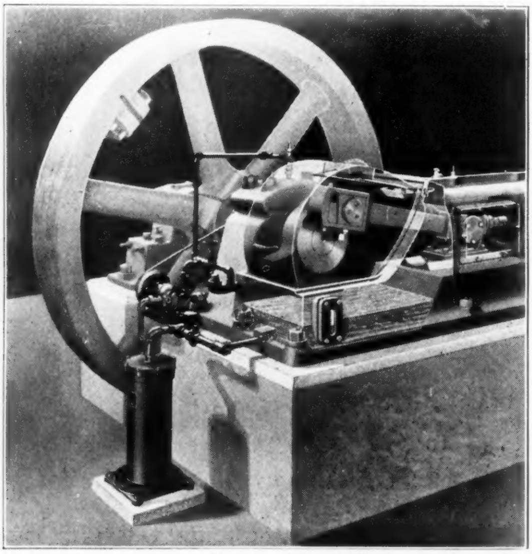
In addition to lubrication via the ring oilers, in the centrifugal type of compressor, the lubricating oil performs another function in that it serves to maintain an automatic oil seal against loss of vacuum. This is aptly explained by the Carrier Corporation* as follows: "There is no 'stuffing box' or packed gland, requiring manual adjustment upon starting and frequently during operation. Instead, an automatic oil seal requiring no attention at any time, starting, running or at rest, prevents leakage or loss of vacuum. The thru-shaft, at the drive end of the compressor, is sealed against inward leakage (i.e., loss of vacuum), by an automatic mechanism actuated by the oil pressure while running and by springs when at rest. The seal comprises a rotating and a stationary disk, held in position by the oil pressure and separated from actual wearing contact by a film of oil under pressure. When the machine is stopped and the oil pressure ceases compression springs are automatically released and these then effect an equally dependable and leak-proof seal while the machine is inoperative."

VISCOSITY

In the lubrication of refrigerating machines, the viscosity or body of an oil must be considered with particular respect to the design of the lubricating system. In the enclosed crankcase type of compressor the operating tempera-

*Carrier Engineering Corporation handbook on Carrier Centrifugal Refrigeration.

ture of the case also becomes a factor. In such machines splash lubrication is generally provided for. By reason of the severe service to which the oil is subjected due to churning, especially in the presence of a certain amount of refrigerant, it must be of the highest degree



Courtesy of Carrier Engineering Corporation Brunswick-Kroeschell Division

Fig. 8—Showing oiling system of horizontal CO_2 compressor, with phantom view of crank end.

of refinement and of sufficient original viscosity to resist abnormal reduction in body when mixed with refrigerants such as Freon.

In this regard it must be borne in mind that the one oil must lubricate the entire machine. Centrifugal compressors involve only ring oiled bearings. On the other hand, in such machines the oil must also maintain an adequate seal against loss of vacuum. Viscosity, of course, plays a part in this respect just as it does in lubrication; it could normally be expected that marked reduction from the accepted standard of approximately 300 seconds Saybolt at 100 deg. Fahr., might seriously affect the seal forming properties. Too heavy an oil, in turn, might lead to a decided increase in bearing temperatures on account of internal or fluid friction. This would cause reduction in viscosity of the oil film, and might also impair the seal.

In view of the fact that the viscosity or body of any oil is directly affected by temperature, this characteristic must be thoroughly understood wherever oils are to be selected to meet low temperature operating conditions.

It is a characteristic of most liquids to become thinner or more fluid when subjected to an increase in temperature. For the information of the layman, in the petroleum industry this is termed reduction in viscosity. It will be of further advantage to state that viscosity is regarded as a measure of the relative fluidity of an oil at some definite temperature of observation. In brief, it is that inherent property by virtue of which the flow of certain liquids will be retarded. It is possessed by all lubricating oils to a varying degree, depending on their source, range of distillation, and extent of refining or blending.

As a result, wherever abnormally high or low temperatures must be encountered, the operating viscosity of the lubricant must be given the most careful consideration. Simply because the temperature of the lubricant may be more or less controlled prior to application or circulation to the wearing elements is no criterion that its operating viscosity in service will be able to maintain an adequate lubricating film. Attention must be given to the operating temperatures, and the original oil selected with this in view.

This will call for the utmost care in the selection of the proper grade of lubricating oil for low temperature operation. Haphazard choice without adequate knowledge of the approximate operating viscosity of the proposed oil may be the forerunner of too great a variation in the fluidity of the oil in service, with oftentimes ineffectual lubrication of certain of the wearing parts.

In the reciprocating compressor the oil must be capable of serving both the cylinders and bearings. It should not emulsify to any great extent, for this might result in clogging of the lubricating system or impairment of refrigeration should it work past the piston rings and over to the refrigerating side.

The physical condition of the valves, piston rings and stuffing boxes must always be considered in deciding upon the viscosity of oil to use.

Here as well as in the centrifugal compressor the seal and compression-forming ability is of great importance. If the cylinder wall and moving parts are in first-class condition, a straight mineral oil of from 150 to 300 seconds Saybolt viscosity at 100 degrees Fahr., has been found to be satisfactory.

The more worn and scored the cylinder walls and rings, naturally the higher must be the viscosity, commensurate with the pour test, to maintain the requisite seal and degree of compression.

Horizontal compressor cylinders will have a greater tendency to wear out of round than those of vertical machines. Therefore, such compressors will, in general, require a somewhat heavier lubricant. It is not advisable, however, to attempt to compensate for wear by increasing the viscosity too much, due to the possibility of emulsification, and contamination of the refrigerant as mentioned above.

POUR TEST INDICATIVE OF FLUIDITY

Low pour test is one of the outstanding characteristics which must be indicated in lubricating oils intended for service in refrigerating machinery attached to air conditioning or comfort cooling systems. Obviously the oil must remain comparatively fluid at the lowest temperatures to which it may be subjected during operation. As a general rule these will be encountered beyond the expansion valve, in the expansion or refrigerating side of the system.

Pour test is a characteristic which is dependent upon the base of the oil, the manner in which it has been refined and to some extent upon the viscosity. Oils for refrigerating service must, therefore, be studied from this viewpoint, in conjunction with their viscosity, for upon this latter property will depend the body of the film which must prevent metallic contact between the moving parts, and the readiness with which the oil can be circulated by splash or ring oilers.

The wax content will normally be the controlling factor in regard to pour test or relative fluidity at low temperatures. All petroleum products contain a certain amount of wax, some more than others. The wax content of paraffin base crudes is considerably more prominent than in the naphthenic series. It is also more difficult to remove during refinement. As a result, unless a paraffin oil has been especially dewaxed it will show a considerably higher pour test than a naphthenic product of the same viscosity.

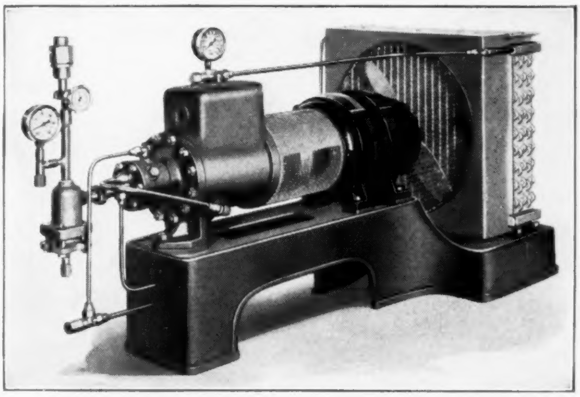
This presence of wax is the cause of congealment when certain oils are exposed to lower temperatures.

Congealment will mean that a film of oil will be deposited on the inner surfaces of the refrigerating piping, to form more or less of an insulating medium which will prevent proper abstraction of heat from the compartment or medium which is to be cooled. If this is allowed to continue it is evident that the refrigerating capacity of the system will be reduced and ultimately it will be necessary to clean out these congealed oil deposits.

Oils Must be Free From Water

The possibility of congealment requires that consideration be given to water. It is essential that the oil at all times be practically free from water, otherwise this will freeze if carried over to the refrigerator coils, in which case it would probably remain in the system and result in a certain decrease in evaporative efficiency. For this reason, certain authorities regard the water-free requirement as one of the most important phases of the lubricating oil specification.

An oil, to be suited to this class of service, should have a pour test sufficiently low to insure continued fluidity at the lowest temperatures prevalent in the evaporating side of the system. It should not congeal on the inner surface of the cooling coil, and there should be



Courtesy of The Vilter Manufacturing Company

Fig. 9—Showing a typical air cooled Vilter rotary refrigerating machine. Lubrication and cooling of the compressor is effected by a pressure pump in the larger sizes and by an oil circulating and cooling system in all sizes. Where no pressure pump is used the oil is cooled partly by thermostatic action and partly by the simple circulating arrangement.

sufficient viscosity throughout the range of operating temperatures to enable it to serve at all times as an effective lubricant for the moving parts, as well as an adequate seal for the piston rings and compressor valves.

Filtered Mineral Oils Most Suitable

For such service a straight mineral filtered oil, having a viscosity of from 150 to 300 seconds Saybolt at 100 degrees Fahr., will be necessary where the temperature in the refrigerating coil is below 5 degrees Fahr. Above this temperature, however, an oil of somewhat higher viscosity, will be required, according to certain authorities.

The purest grade of straight distilled mineral oil obtainable is always advisable in order that the above requirements will be adequately met. Oils of this nature will have a sufficient range of physical properties to lubricate compressors effectively under all normal operating conditions.

Animal and vegetable oils are not suitable for such service, inasmuch as they will have a tendency to congeal at low temperatures and gum at higher temperatures. They will also react to a certain extent, to cause the formation of sludge.

Pour Test Controlled by Dewaxing

The relation of pour test and comparative fluidity of lubricating oils to their wax content requires thorough appreciation of the importance of the dewaxing stage of refinement. The

several methods employed have been aptly discussed by Manley,* before the Society of Refrigerating Engineers.

"Refining Processes

"The refining of lubricating oil in general consists in the following unit operations:

"(1) Separation of lubricant fractions from the crude by distillation, removing fractions either as distillates or as residual oils.

"(2) Refining of raw lubricating stocks by chemical treatment or by filtration, or by both processes.

"(3) Removing waxes from the lubricating oil stock, by crystallization from a non-viscous solution, with subsequent mechanical separation by filtration, centrifugal force or cold settling.

"(4) Finishing dewaxed oil by chemical treatment, redistillation, or filtration with an absorbent material or by combinations of these processes.

"In the past the sequence of refining steps has been limited by the dewaxing methods, due to the serious difficulties encountered in removing waxes, which were crystalline in structure, from extremely viscous media. It was necessary to manufacture paraffin base oils by blending a low viscosity lubricant, derived from an oil which was pressed for wax removal, with a highly refined viscous residual oil or cylinder stock.

"In the last five years, however, the development of highly efficient vacuum distillation equipment has given the refiner the opportunity of obtaining a distillate lubricating oil having a narrow boiling range for any required viscosity, a lower volatility, and reduced carbon forming tendencies."

"Dewaxing Processes

"Dewaxing of the more viscous lubricating oils consists in the following unit operations:

"(1) Dilution of the lubricating oil stock to establish conditions favorable to wax crystallization, followed by removal by mechanical means.

"(2) Chilling of the oil and wax solution to precipitate the wax.

"(3) Separation of the precipitated wax by settling, centrifuging, or filter pressing.

"(4) Removal of diluent from the dewaxed lubricating oil solution by stripping.

"In the case of the so-called pressable distillates, the lubricating fractions are relatively non-viscous and can be filtered from the wax in a pad and ring type press without dilution. Generally, it is impracticable to press oil of this low viscosity at very low temperatures. This method is, therefore, limited to the production of a light lubricating oil fraction having a pour point of 15 degrees Fahr., to 20 degrees Fahr.

"The following processes of dewaxing are now being applied in commercial practice in lubricating oil refineries:

"(1) Old method of direct pressing of low viscosity distillate. This method has recently been modified somewhat to dewax to lower pour points.

"(2) Cold settling (petrolatum wax) from naphtha solution of heavy residual oil.

"(3) Centrifugal separation in centrifuge of petrolatum from naphtha solution of heavy residual oil, in some cases applicable to a very viscous overhead distillate.

"(4) Filtration in the presence of a filter aid to remove wax from either distillate or residual oils of all viscosities.

"(5) Dewaxing by filtration, employing special solvents which promote crystallization of wax in a directly filterable form."

"Method (4) is applicable to the removal of any wax which can be precipitated by chilling or wax of any type." By reason of its flexibility and adaptability to a wide variety of stocks of either residual or distilled origin, further discussion is of interest.

"The filter aid process of dewaxing consists in the following unit operations:

"(1) Dilution of the waxy lubricating stock with naphtha.

"(2) Chilling for precipitation of waxes (usually 25 degrees Fahr., to 40 degrees Fahr., below the pour desired on the dewaxed oil.)

"(3) Addition of filter aid to the chilled solution.

"(4) Pressing on totally enclosed leaf-type pressure or vacuum filter, for removal of wax and filter aid.

"(5) Recovery of filter aid by washing with warm naphtha in a closed system.

"(6) Stripping wax free oil and wax concentrate for the removal of diluent."

"The filter aid process is applicable to removal of either crystalline or "amorphous" wax from oils of any viscosity, whether residual or overhead distillates. The process can be employed for the clarification of wax from California or coastal lubricants which contain wax crystals in visible quantities, and cloudy, in completely dewaxed paraffin oils. It can be used to dewax a partially dewaxed oil to a lower pour point, or recover valuable oil from slack wax or petrolatum.

"The filter aid process does not depend on, nor is it limited by, any definite gravity difference, crystal structure or previous refining which may influence crystal formation and growth and is certainly the most universally applicable dewaxing method available to the industry."

*R. E. Manley Refrigerating Engineering May, 1932.

Printed in U. S. A. by
Edgar C. Ruwe Co., Inc.
72 Washington St., N. Y. C.